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The Agricultural Survey and Postharvest Handling Research of Avocado In Taiwan

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Abstract

The technology for improving postharvest handling from growing field to consumers has been the major subject of detailed research for over a century. The cost for harvest and postharvest up to 30% to 60% of all production and marketing system during horticultural produce, and significant quality loss due to improper processing. Technologies involved in handling, packaging, precooling, transportation, which would minimize losses, maintain high quality, and enhance value-added for horticultural crops that had been extensively applied in Taiwan. For example, precooling is the most common practice, and forced air cooling and vacuum cooling are widely adapted. In this article, information of current postharvest technology in Taiwan, including value, production, and planted area of fruits and vegetables, will be discussed. Avocado is a developing fruit in Taiwan. Postharvest methods of avocado have been tested, including storage temperature, storage period, the effect of ethylene absorbent and the effect of ethylene inhibitor. By some of these methods, avocado can be maintained in good appearance and quality.

Introduction of Taiwan's Agriculture and Postharvest Handling of Fruits and Vegetables

The total population of Taiwan is about 23.1 million people in 2009. The agricultural employed population is 543 thousands, with male population of 70.02% and female of 29.98% in 2009. The gross domestic production (GDP) is 383,343 million USD in 2007 and 402,616 million USD in 2009. The gross national production (GNP) per capita is 17,252 USD in 2007 and 17,651 USD in 2009, according to the statistic table from Directorate-General of Budget. Taiwan's GNP is predicted inceasing to 18,565US$ in 2010. The gross domestic product based on purchasing-power-parity (PPP) per capita GDP from 1980 to 2009 is from 4,000US$ to 29,000US$ (Fig. 1).

The industrial origin of gross domestic product is 417,089 million USD in 2009 and agricultural industry shares almost 1.55%. The composition of crop products in agricultural production is 5960.6 million USD, about 43.9% of total agricultural products, in 2009. Horticultural crops contributed 70.20% of total value of all crops products in 2009 (Table 1 and Fig. 2). Fruit crops and vegetable crops are the most important, 26.59% and 36.75%, respectively, of all crops. In Taiwan, consumers usually buy fresh fruits and vegetables in the markets.

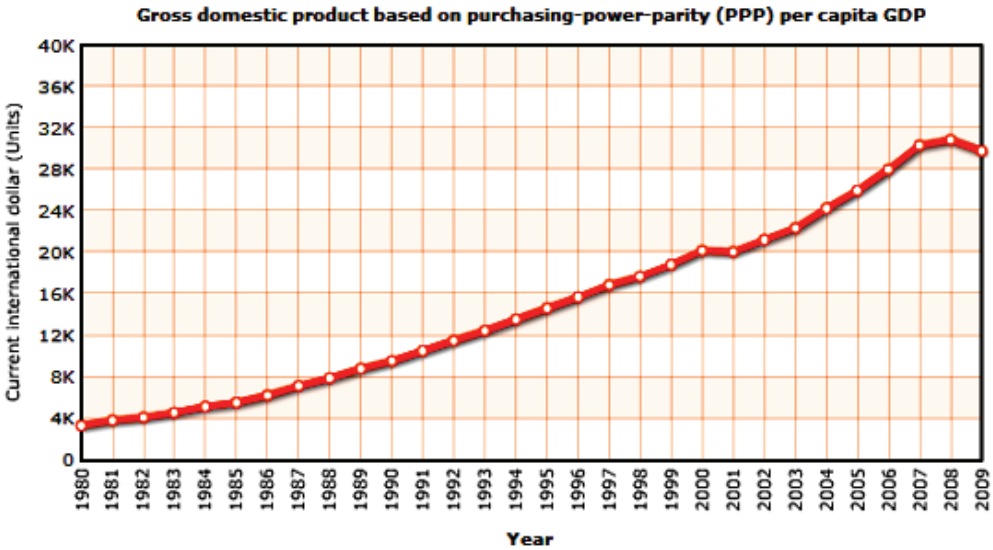

Fig. 1. The GDP based on PPP per capita GDP.

Table 1. The composition of crop products in agricultural production from 2006 to 2009

	Value				Percentage			
Item	2006	2007	2008	2009	2006	2007	2008	2009
Crop production	5756384.4	5612282.0	5970266.7	5960575.0	45.81	43.36	42.90	43.92
Rice	979330.7	869711.4	1045424.9	1125833.8	7.79	6.72	7.51	8.30
Coarse grain	266627.7	209165.1	243573.8	252228.5	2.12	1.62	1.75	1.86
Special crops	270584.8	262651.7	276142.7	280557.9	2.15	2.03	1.98	2.07
Vegetables	1467589.5	1565726.4	1617134.9	1585602.4	11.68	12.10	11.62	11.68
Mildew	99361.4	106380.3	122089.1	118068.3	0.79	0.82	0.88	0.87
Fruits	2255521.5	2186511.6	2271561.3	2190244.3	17.95	16.89	16.32	16.14
Flowers	417368.8	412135.5	394340.0	408039.7	3.32	3.18	2.83	3.01

Note: the production unit is ton.

Taiwan has a mild climate, allowing the production of fresh fruit and vegetables throughout the year. More than 100 different kinds of vegetables are grown as well as various kinds of fruits are planted and cultivated. The major vegetables and fruits species are listed in Table 2 and Table 3. At the same time, owing to climate tends to be warm and humid, it has taken great efforts to reduce postharvest losses to their present level of 10% for both vegetables and fruits (FAO/ Food Balance Sheet). In order to maintaining high quality of fresh produce, cold chain system has been applied since 1960 in Taiwan. At present lots of vegetables and fruits are sold through this system.

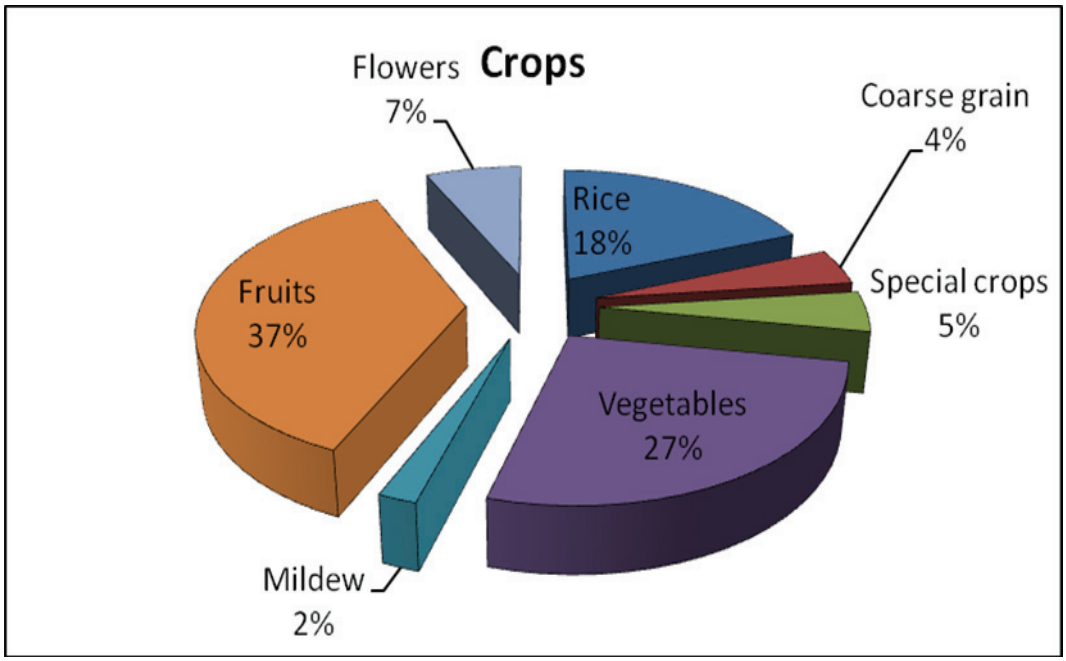

Fig. 2. Fruits crops and vegetable crops are 26.59% and 36.75%, respectively, of all crops.

Table 2. The value, production and planted area of major fruits in Taiwan in 2009

Species	Value (1000US$)	Production (MT)	Planted area (ha)
Citrus	6853533	458813	24062
Pineapple	6238070	434769	11236
Mango	5064466	140290	17130
Pear	5079179	153450	8132
Grape	4311093	98091	3225
Banana	4400020	172550	12349
Longan	2663917	82602	11790
Sugar apple	2885177	70370	5987
Lychee	3113723	95440	12015
Guava	2739882	135303	7225

Table 3. The value, production and planted area of major vegetables in Taiwan in 2009

Species	Value (1000US$)	Production (MT)	Planted area (ha)
Bamboo shoot	230154.7	251994	27045
Other leafy vegetables	126681.4	242723	17556
Cabbage	109660.8	346297	8371
Scallion	96500.4	111347	5368
Watermelon	81244.6	217619	11925
Garlic bulbs	74399.9	49600	5477
Tomato	67985.4	99491	4104
Water bamboo	60789.4	46169	2057
Cauliflower	46068.8	76569	2976
Muskmelon	24840.0	26147	2099

However, extended cold storage always result in physiological disorders and abnormal fruit ripening, reducing consumer acceptance. In many commodities the severity of chilling injury (CI) increases when the fruit is refrigerated for prolonged periods at close to 0℃, but above fruit freezing point. These symptoms are important to commercial business since shipping of fruits to distant markets and storage before selling. In the past report of Taiwan, the guava symptoms of chilling injury appeared when fruits were stored at 1℃ to 5℃ for a period of 7 to 12 days and then placed at 20 to 25℃ for 3 days. Guava fruit shows that abnormal ripening, pulp browning and water-soaking core, and the data suggest that 5℃ to 10℃ is the appropriate temperature for storage. For this reason, several physiological and physical researches of fruits and vegetables preventing chilling injury and other storage methods are developed. Furthermore, extension storage life and export horticultural products to markets in other country are always the continuously pursue goal of the industry.

Postharvest Handling of Avocado in Taiwan

Introduction

Avocado (*Persea Americana* Mill.), which has been referred as the most nutritious of all fruits, has worldwide recognition and significant volume in international trade. The unique fruit has been appreciated and utilized for at least 9,000 years in and near its center of origin in Meso-America. It is a polymorphic tree species that apparently originated in a broad geographical area stretching from the eastern and central highlands of Mexico through Guatemala to the Pacific region of Central America. Avocado produced a green-skinned, pear-shaped fruit that ripens after

harvesting, and is partially self-pollinating and often is propagated through grafting to maintain a predictable quality and quantity of the fruit.

Ecological races and adaptations

There were three distinct ecological species of avocado: The Mexico, Guatemalan and West Indian races. The Mexico species is grown at high elevated (1400-2500m) and cooler (14-19.8℃) areas, with rainfall from 600 to 1600mm and a half year dry season from winter to spring. The Guatemalan species is grown in the less extreme conditions. They are common in tropical highlands with all year-round cool conditions. The West-Indian avocado species is grown in lowland and in hot and humid Central American forests with a short dry season.

World production and fruit composition

Total world avocado production increased approximately 3.3- fold over 35-year period, from 697,869 tons reported from 76,770 ha in 1961 to 2,303,389 tons harvested from 339,141 ha in 1996. According to FAOSTAT Database, Mexico is the country that producing the most avocados around the world, Indonesia is the second, and the United States of America is the third (Table 4).

The data is collected from FAO statistic database

The avocado fruit is a traditional staple in Guatemala and nearby countries, the daily food of the labouring individual. It is also an ingredient of widely consumed for traditional foods. In some countries the fruit is eaten with sugar, in ice cream or mixing with milk. Avocados are high in valuable fats and appear to have a beneficial effect on blood serum levels. Avocados also have 60% more potassium than bananas, and rich in vitamins B (Table 5).

Table 4. The avocado production countries

Rank	Country	Produciton Value (US 1,000)	Production (MT)
1	Mexico	668,586	1,040,390
2	Indonesia	169,381	263,575
3	United States of America	137,523	214,000
4	Colombia	119,408	185,811
5	Brazil	112,460	175,000
6	Chile	104,749	163,000
7	Dominican Republic	89,968	140,000
8	Peru	65,548	102,000
9	China	54,624	85,000
10	Ethiopia	52,374	81,500

Table 5. The nutritional value per 100g avocado fruit

Item	Avocado, raw (edible parts)
	Nutritional value per 100 g (3.5 oz)
Energy	670 kJ (160 kcal)
Carbohydrates	8.53 g
Sugars	0.66 g
Dietary fiber	6.7 g
Fat	14.66 g
Protein	2 g
Thiamine (Vit. B_1)	0.067 mg (5%)
Riboflavin (Vit. B_2)	0.130 mg (9%)
Niacin (Vit. B_3)	1.738 mg (12%)
Pantothenic acid (B_5)	1.389 mg (28%)
Folate (Vit. B_9)	81 μg (20%)
Vitamin C	10 mg (17%)
Magnesium	29 mg (8%)
Phosphorus	52 mg (7%)
Potassium	485 mg (10%)
Zinc	0.64 mg (6%)

Percentages are relative to US recommendations for adults. (Source: USDA Nutrient database).

Research of postharvest handling of avocado in Taiwan.

In Taiwan, there are about 875 ha planted with avocado trees, and is considered as a new growing fruit industry. Avocados was imported first time in 1930. The avocado fields are spreaded in Chiayi and Tainan counties. The objectives of the research were to search for the most suitable storage conditions of the 'CASE3' avocado fruits, which is a popular variety in Taiwan and bred by TARI. The shape of 'CASE3' fruit is like pear and seed is middle size. The fresh weight, seed weight, dry matter content and crude fat content of 'CASE3' avocado fruits increased with the delaying of harvest date. Its major harvest season is from August to October.

The effect of different storage temperature and storage period to the fruit quality

The ripening quality of 'CASE3' avocado fruits are influenced by storage temperature and time. High temperature will induce rotten while low temperature will induce chilling injury. In order to know the effect of storage temperature and storage period of 'CASE3' fruit quality, fruit were stored at different temperatures at 1, 3, 6, 9, 12, 15℃ for 2, 4, 6, and 8 weeks, respectively.

After storage, fruits were treated with Ethrel (diluted 1000X) for 12 hours and stored at 25℃, 85% RH to observe the change of their quality. of fruit. The result (Fig. 3, Table 6) shows that 'CASE3' avocado fruits stored at 1℃and 3℃ after two weeks would exhibit chilling injury (CI) symptom, as peel color change abnormally and pulp could not soften normally. Fruit pulp stored at 6℃ after 8 weeks might soften, but fruit pulp mostly become brown The fruit produced fetid odor and lost the edible value. Fruit pulp which stored at 9℃ after 4 and 6 weeks could soften normally, and the color of pulp was in normal yellow. The fruits stored at 12℃ after 4 weeks would be soften rottenly, similar result at 15℃ after 2 weeks storage. These results indicate that optimal storage temperature for 'CASE3' avocado fruits is 9℃ and the fruit could ripen normally without pulp browning after storage for 6 weeks.

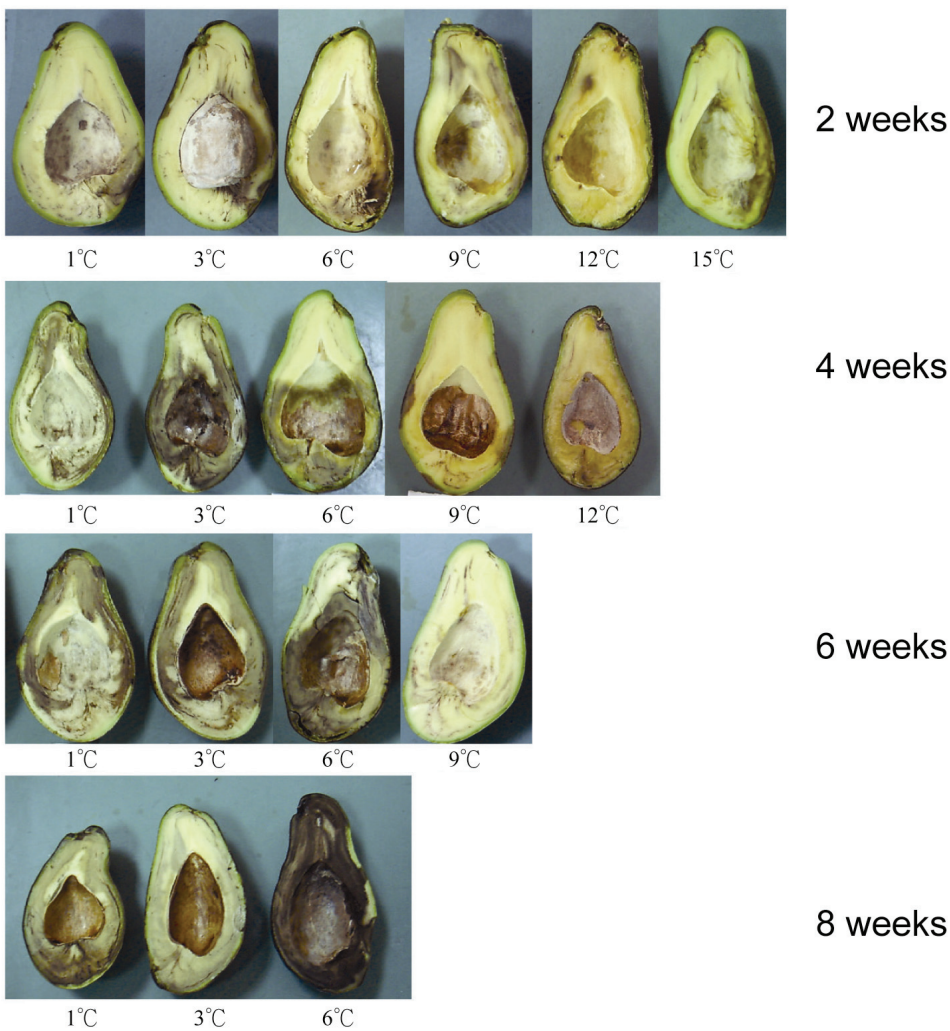

Fig. 3. The fruits of “CASE3” avocado stored at1, 3, 6, 9, 12, 15℃ for 2, 4, 6, and 8 weeks, respectively. (Source: Dr. Ching-Chang Shiesh)

The influence of ethylene absorbent on avocado fruit

The avocado (*Persea americana* Mill.) is a climacteric fruit that is characterized by a surge in ethylene production at the onset of ripening. This climacteric increase in ethylene production is associated with hastened ripening. Avocado is one of the most rapidly ripening fruits. It often ripen completely within 5 to 7 days after harvest.

To know the influence of ethylene absorbent on avocado fruit, ethylene absorbent was put in the PE bag with fruits stored at 9℃ for 2 months. After the fruits were treated with Ethrel (diluted 1000X) for 12 hours and stored at 25℃, RH:85% to observe the quality of fruits, color of pulp and peel turn brown and pulp became soft after four days of treatment. The fruits treated with ethylene absorbent maintained normally in peel color and pulp firmness.

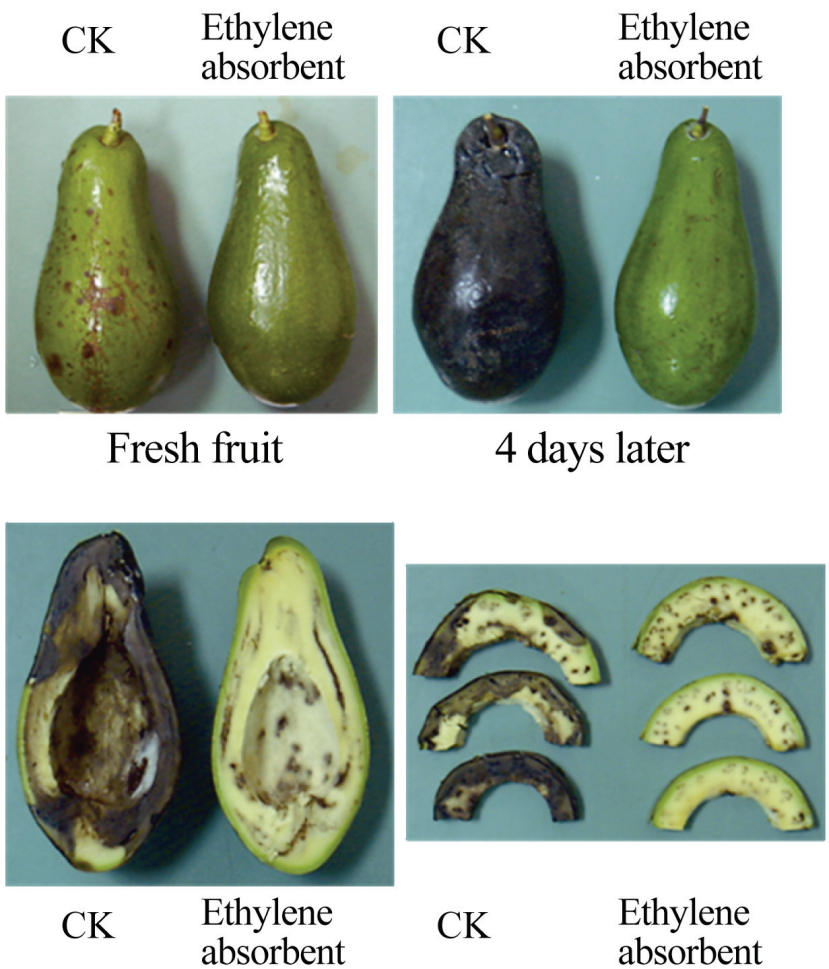

Fig. 4. The effect of ethylene absorbent on avocado fruits 4 days after storage at 9℃ for 2 months and Ethrel treatment. (Source: Dr. Ching-Chang Shiesh)

Table 6. The pulp firmness of "CASE3" avocado fruit stored at 1, 3, 6, 9, 12, 15℃ for 2, 4, 6, and 8 weeks, respectively

Storage temperature	Pulp firmness (N) Storage time			
	2 weeks	4 weeks	6 weeks	8 weeks
H	26.6 a[z]	26.6 b	26.6 b	26.6 b
1℃	3.9 b	131.0 a	261.8 a	199.8 a
3℃	3.1 b	115.6 a	238.8 a	214.7 a
6℃	0.3 b	12.1 b	5.3 b	5.3 b
9℃	0.0 b	3.4 b	6.6 b	--
12℃	0.0 b	0.0 b	--	--
15℃	0.0 b	--	--	--

[z] Means with same letters within a column are not significantly different by Duncan's Multiple Range Test at 5% level.

[y] H=evaluated after ripening at 25℃ for 4 days, no stored.

Table 7. The influence of ethylene absorbent on pulp color and pulp firmness

Treatment	Pulp color					Pulp firmness (N)
	L	a*	b*	C	H	
CK	35.4 b[z]	9.1 a	15.3 b	18.0 b	58.1 b	26.7 a
Ethylene absorbent	67.7 a	2.6 b	41.8 a	42.2 a	85.7 a	6.6 b

[z] Means with same letters within a column are not significantly different by Duncan's Multiple Range Test at 5% level.

The influence of ethylene inhibitor (1-MCP) on avocado fruit

1-MCP (1-methylcyclopropene) has been shown to delay ripening and improve storage quality of climacteric fruits including avocado. 1-MCP and fruit was both put in a 0.03 mm thickness PE bag. In control the fruit was put in PE bag without 1-MCP. Then they were stored at 9℃ for 4 to 6 weeks. After storage, they were treated with Ethrel (diluted 1000X) for 12 hours and kept at 25℃, 85% RH for 4 days to observe the quality of fruits. In Table 8 , the peer color of fruit treated with 1-MCP has higher L , b*, C and H value. The a* value is -8.2 compared to the control with a value of 7.5. The peer color without 1-MCP turn red while the peer color of 1-MCP treatment maintained normal green. The pulp color of fruit of 1-MCP treatment is better than control. Both of them have high firmness. On the other hand the respiration rate and ethylene production rate of fruits treated with 1-MCP are higher than control after have treated with Ethrel (Table 9).

Table 8. The effect of 1-MCP treatment on the peel color and pulp color of avocado fruits.

Treatment	L	a*	b*	C	H
Peel color					
CK	32.7	7.5	17.7	20.1	63.7
1-MCP	47.3	-8.2	35.6	36.5	102.7
Treatment	L	a*	b*	C	H
Pulp color					
CK	66.9	-0.6	42.4	42.6	90.5
1-MCP	71.5	-2.2	46.3	46.4	92.4

Table 9. The respiration rate, ethylene production, and firmness of avocado fruits after treated with 1-MCP.

Treatment [z]	Respiration rate ($mlCO_2$/kg-hr)	Ethylene production rate (μl C_2H_4/kg-hr)	Firmness (N)
CK	115.0	1.6	8.4
1-MCP	122.7	90.5	110.7

Conclusion

Many countries wish to export their products to other countries. Difficulty exists in passing the quarantine requirements imposed by importing countries. The development of more advanced technologies on this purpose should be emphasized and proceeded continuously. Until now, high quality, safety, and good appearance become more important at present and future. Recent progress has been based on good cooperation between postharvest scientists and government coordinators. It helps in improving the quality of fresh produce at the markets. Farmers can get the benefits from reduced postharvest losses and increased value-added products.

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